LA-UR-21-24780
Approved for public release; distribution is unlimited.

Title: Risk Introduction — Qualitative & Quantitative Risk Management

Author(s): Kniss, Paul Ryan
Sherwood, John Gregory
Booth, Steven Richard

Intended for: Generic Risk Introduction Presentation

Issued: 2021-05-18

Los Alamos NATIONAL LABORATORY

Risk Introduction — Qualitative & Quantitative Risk Management

Paul Ryan Kniss E-2 Model and Process Analysis

Steve Booth E-2 Model and Process Analysis

John Sherwood E-2 Model and Process Analysis

April 2021

LA-UR-????

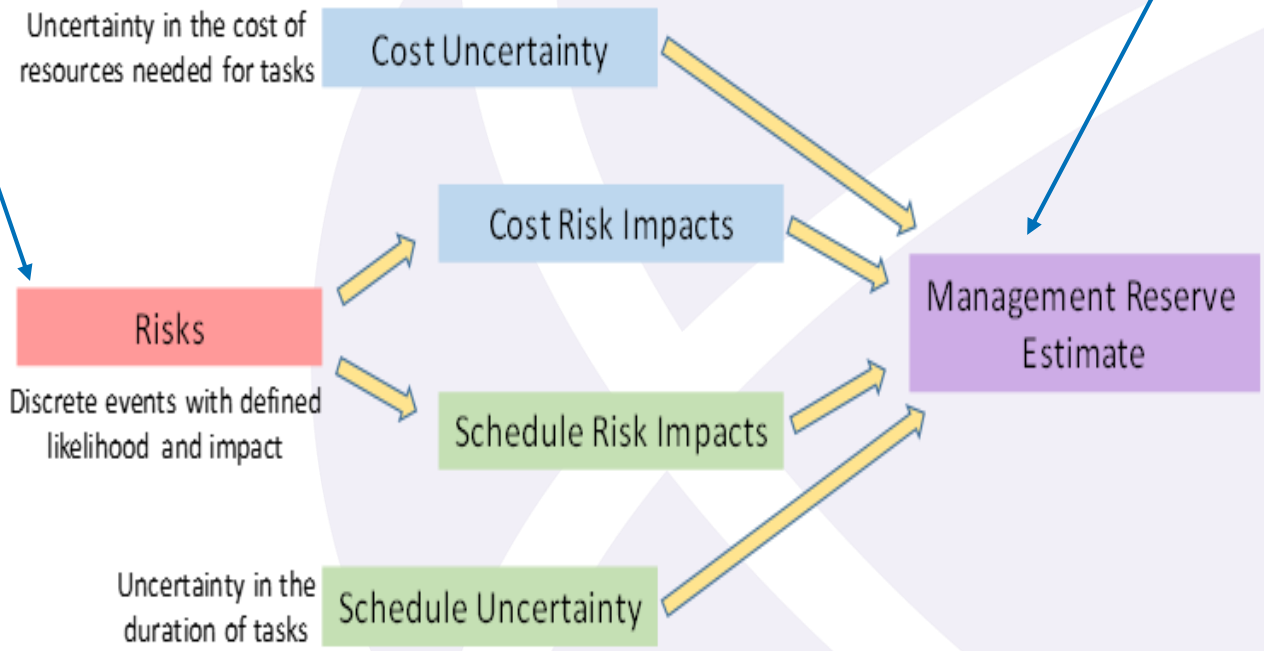
Topics

- Risk and Uncertainty
  1. Risk & Uncertainty Definitions
  2. Risk Register
  3. Risk Matrix
  4. Handling Strategies
- Schedule, Cost, and Uncertainty Risk Analysis (SCURA)
  1. Schedule Risk Analysis (SRA)
  2. Cost Risk Analysis (CRA)

Risk and Uncertainty Overview

1. Typical (Qualitative) Risk Management

2. Acumen Risk® (Quantitative) Simulations



Los Alamos NATIONAL LABORATORY

Qualitative Risk Analysis:

Risk and Uncertainty

Paul Ryan Kniss E-2 Model and Process Analysis

Steve Booth E-2 Model and Process Analysis

John Sherwood E-2 Model and Process Analysis

Definitions

- **Risk** – An event or condition that, if it occurs, has a negative effect on one or more project objectives such as scope, schedule, cost, and quality.
- **Uncertainty** – Uncertainty directly correlates to how much is known about the project and relates to how estimates of cost and duration of scheduled activities are applied by project teams.
- **Management Reserve (MR)** – A theoretical calculation of the probabilistic impact in dollars based on uncertainty analysis and risk pool, for a given point or period in time.
- **Schedule Impact** – The total number of days required to respond/recover after a risk is realized
- **Cost Impact** – A total response/recovery amount if the risk is realized.

Risk Register

- Managed using Active Risk Management (ARM) and will be utilized for each internal review, site risk review board, and federal review.

- Captures:

- Candidate and monitored risks
- Risk statements and risk owners
- Trigger & sunset dates
- Likelihood, cost & schedule consequences
- Risk levels (red, green, yellow), risk handling strategies & plans, and target scores following handling strategies.

Typical (Qualitative) Risk Management Risk Matrix and Scores

		Threat				
Likelihood	Very High	5	11	***19***	***21***	***25***
	High	4	10	14	***20***	***24***
	Moderate	3	8	13	17	***23***
	Low	2	7	12	16	***22***
	Very Low	1	6	9	15	18
		Very Low	Low	Moderate	High	Very High
		Consequence				

Handling Strategy

- Four options for addressing risk

Accept: Include in baseline

- “Monitor” approach

Avoid : Eliminate likelihood or consequence

- Lowering the likelihood of occurrence to zero and/or eliminating the consequences of the risk

Mitigate : Reduce Exposure

- Reduces the likelihood and/or consequence to a lower level

Transfer : Allocate Ownership

- Acceptance between the transfer organization and the receiving organization

Los Alamos NATIONAL LABORATORY

Quantitative Risk Analysis:

Schedule, Cost, & Uncertainty Risk Analysis (SCURA)

Paul Ryan Kniss E-2 Model and Process Analysis

Steve Booth E-2 Model and Process Analysis

John Sherwood E-2 Model and Process Analysis

Schedule Risk Analysis (SRA)

- Quantitative schedule risk analysis is based on resource-loaded schedules that allow much more accurate schedule predictions than qualitative risk analysis.
- Inputs are:
  - Logic-linked resource-loaded schedule with level-of-effort tasks removed
  - Definition of activity duration uncertainties
  - Risk register
  - Mapping of risks to activities.
- Results are:
  - S-curves and tornado charts.
    - Statistical simulation provides probabilistic predictions of schedule slip for desired milestones.

Example Risk Register and Active Risk Manager (ARM) Scores

ID	Risk Name	Probability	Schedule {1}	Cost {1}	ARM Score {2}
R1	LV Chiller Failure	Low (25%)	20d, 40d, 60d (per y)	$0.1M, $0.2M, $0.3M (per y)	2
R2	Decon Hood Failure	Medium (50%)	40d, 60d, 80d	$0.1M, $0.2M$, $0.3M	3
R3	UT Equipment Failure	Medium (50%)	5d, 10d, 25d (per y)	$0.1M, $0.2M, $0.3M (per y)	3
R4	Furnace Failure	Low (25%)	10d, 50d, 60d (per y)	$0.1M, $0.2M, $0.3M (per y)	2
R5	Aqueous Line Failure	Medium (50%)	10d, 20d, 30d (per y)	$0.1M, $0.2M, $0.3M (per y)	3
R6	Welders Failure	Medium (50%)	10d, 20d, 45d (per y)	$0.1M, $0.2M, $0.3M (per y)	3
R7	CT Radiography Equipment Failure	Medium (50%)	20d, 30d, 40d (per y)	$0.1M, $0.2M, $0.3M (per y)	3
R8	Metallography Equipment Failure	Low (20%)	10d, 30d, 45d	$0.05M, $0.1M$, $0.2M	1
R9	Hydroxide Processing Failure	Medium (40%)	5d, 15d, 30d (per y)	$0.01M, $0.025M, $0.05M	2
R10	Overlap of Build Schedules	Low (30%)	10d, 20d, 30d	$0.01M, $0.025M, $0.04M	2
R11	MMR Failure	Medium (50%)	20d, 40d, 60d (per y)	$0.1M, $0.2M, $0.3M (per y)	3

SME PREDICTIONS

Welders: 2 to 3 events per year, 1 to 3 weeks per event; $300k to $600k for spare parts and repairs annually across all programs. This program's contribution assumed to be 1/3 of that: $100 to $300k per year.

CT Rad: Requires 4-8 weeks to repair, 6+ months to replace. Cost: 225keV Microfocus ($150k burdened), replacement panel ($190k), backup panel ($70k), backup source ($70k) plus installation.

Focus on two risks with "Accept" handling plan

	Handling Plan			Target			
	Description	Duration	Cost	Probability	Schedule	Cost	ARM Score {2}
R1	Mitigate: Replace aging chillers (proposed)	130d	$30,000	Very Low (10%)	10d, 20d, 30d	Nil	1
R2	Mitigate: Replace Decon Hood (proposed)	100d	$500,000	Very Low (10%)	5d, 10d, 25d	Nil	1
R3	Accept	n/a	n/a	Low (20%)	5d, 10d, 25d	$0.1M, $0.2M, $0.3M	1
R4	Accept	n/a	n/a	Low (25%)	10d, 50d, 60d	$0.1M, $0.2M, $0.3M	2
R5	Mitigate: Replace equipment (proposed)	260d	$2,600,000	Very Low (10%)	Nil	Nil	1
R6	Accept	n/a	n/a	Medium (50%)	10d, 20d, 45d	$0.1M, $0.2M, $0.3M	3
R7	Accept	n/a	n/a	Medium (50%)	20d, 30d, 40d	$0.1M, $0.2M, $0.3M	3
R8	Accept	n/a	n/a	Low (20%)	10d, 30d, 45d	$0.05M, $0.1M$, $0.2M	1
R9	Mitigate: Improve equipment and processes	25d	$100,000	Very Low (10%)	5d, 10d, 15d	Nil	1
R10	Mitigate: Coordinate schedules	20d	$2,000	Very Low (10%)	5d, 10d, 15d	Nil	1
R11	Mitigate: Replace equipment	260d	$1,770,000	Very Low (10%)	Nil	Nil	1

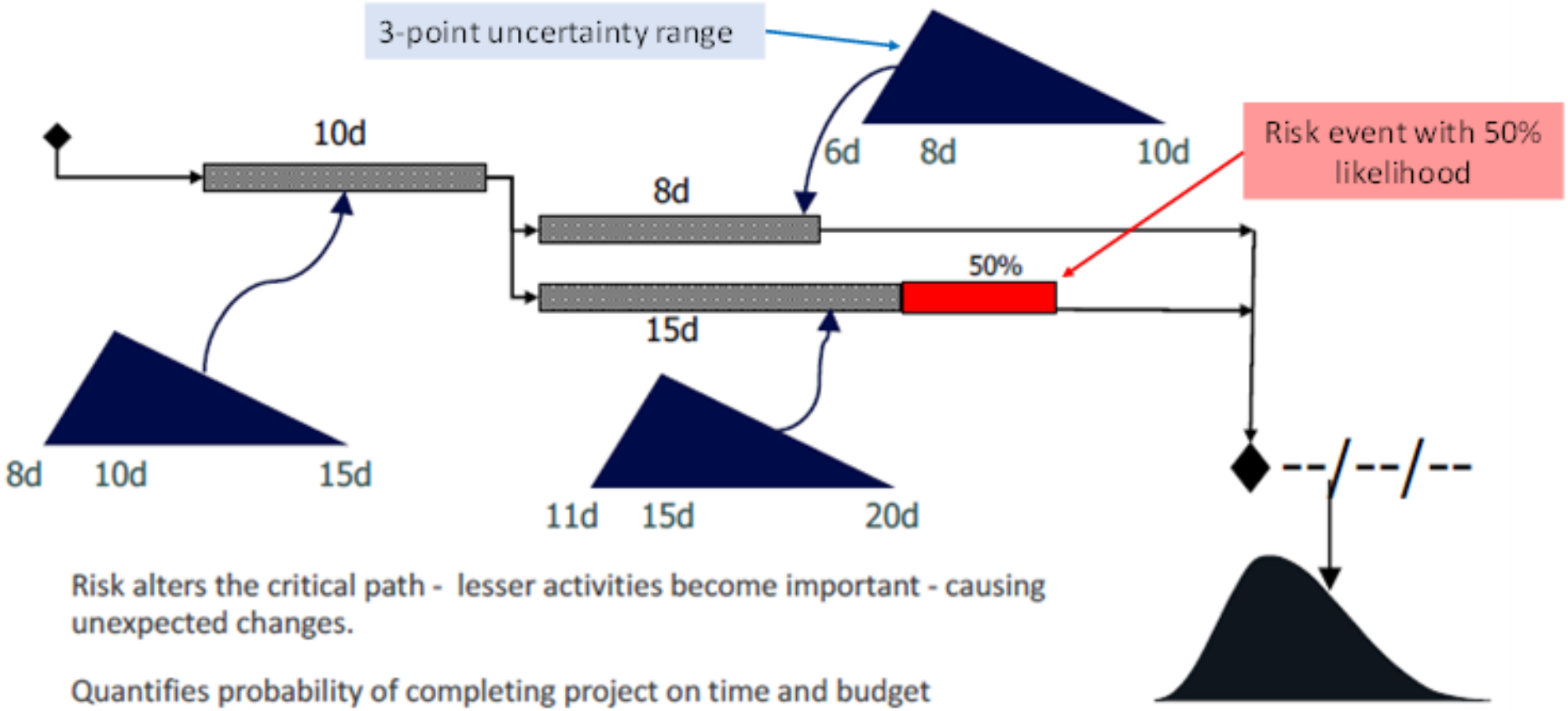
Note that consequence in these tables is different than ARM because ARM looks at program-wide impacts whereas Acumen looks at site impacts.
{1} Entries are mapped to one activity in the Acumen model unless the values are "per year." In these cases the values are applied to several years, as appropriate to the specific risk
{2} Per Federal guidance, ARM scores are based on impact against national integrated schedule rather than site schedule.

Acumen Risk® Requires Mapping of Risks to Activities

ID	Risk Name	Mapped Schedule Activity Description
R1	LV Chiller Failure	Retrieve from Storage & Open Containers Batch #1
		Retrieve from Storage & Open Containers Batch #18
		Retrieve from Storage & Open Containers Batch #36
R2	Decon Hood Failure	Decon - WR Batch #1
R3	UT Equipment Failure	UT (Data Acquisition & Data Analysis) - WR Batch #1
		UT (Data Acquisition & Data Analysis) - WR Batch #25
		UT (Data Acquisition & Data Analysis) - WR Batch #50
R4	Furnace Failure	Retrieve from Storage & Open Containers Batch #1
		Retrieve from Storage & Open Containers Batch #18
		Retrieve from Storage & Open Containers Batch #36
R5	Aqueous Line Failure	Dissolution Batch #1
		Dissolution Batch #18
		Dissolution Batch #36
R6	Welders Failure	Load Charges & GTA Weld - WR Batch #1
		Load Charges & GTA Weld - WR Batch #23
		Load Charges & GTA Weld - WR Batch #47
R7	CT Radiography Equipment Failure	Load Charges & GTA Weld - WR Batch #1
		Load Charges & GTA Weld - WR Batch #23
		Load Charges & GTA Weld - WR Batch #47
R8	Metallography Equipment Failure	Load Charges & GTA Weld - WR Batch #1
R9	Hydroxide Processing Failure	Dissolution Batch #1
		Dissolution Batch #18
		Dissolution Batch #36
R10	Overlap of Build Schedules	Microlaser Wire Weld WR Batch #137 Line B
R11	MMR Failure	Retrieve from Storage & Open Containers Batch #1
		Retrieve from Storage & Open Containers Batch #18
		Retrieve from Storage & Open Containers Batch #36

Two risks impact same three activities

Acumen Risk® Also Requires Estimates of Activity Uncertainty (Cost and Schedule)



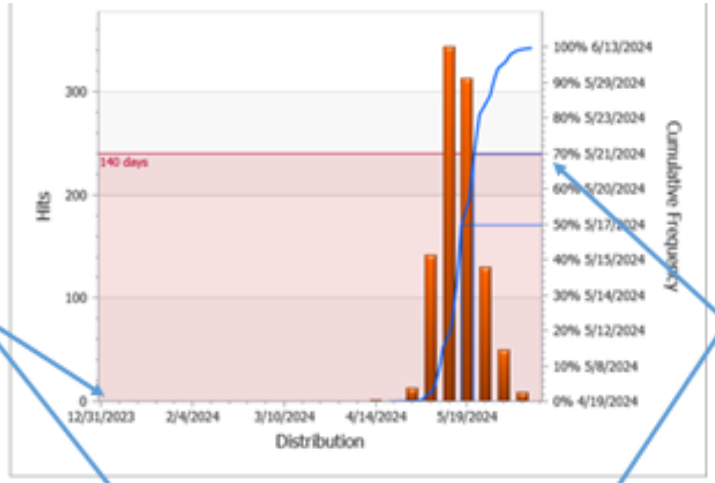
Risk alters the critical path - lesser activities become important - causing unexpected changes.

Quantifies probability of completing project on time and budget

Takes both **uncertainty** and **risk events** into account

Cumulative Probability "S-Curve" for Uncertainty Alone (No Risk Events)

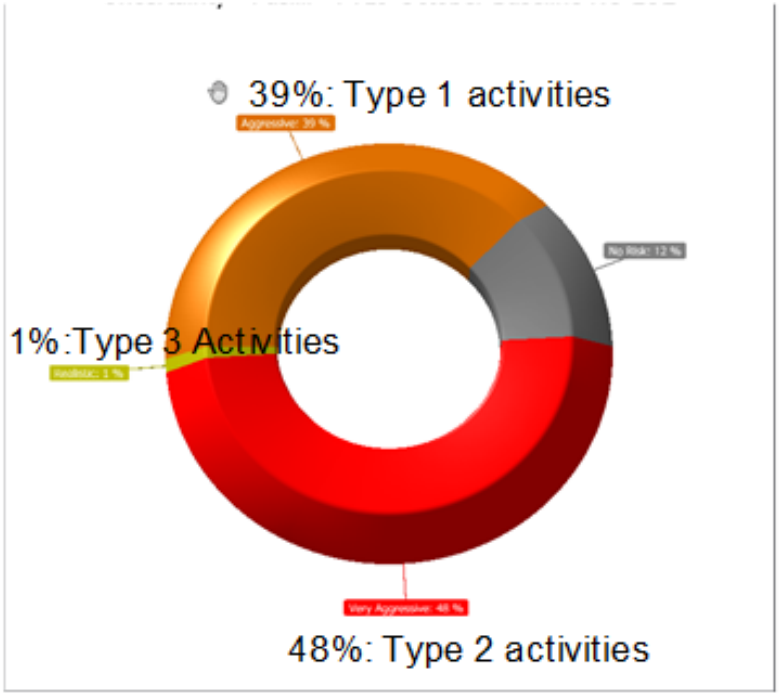
Note there is 0% chance of achieving the P6 point estimate.



Metric	Value
Deterministic - 0 %	1/2/2024
Mean (P55)	5/19/2024
P0 - Best Case	4/19/2024
P50	5/17/2024
P70	5/21/2024
P70 Contingency	140 days
P100 - Worst Case	6/13/2024
Range	55 days
Risk Range Factor	2 %

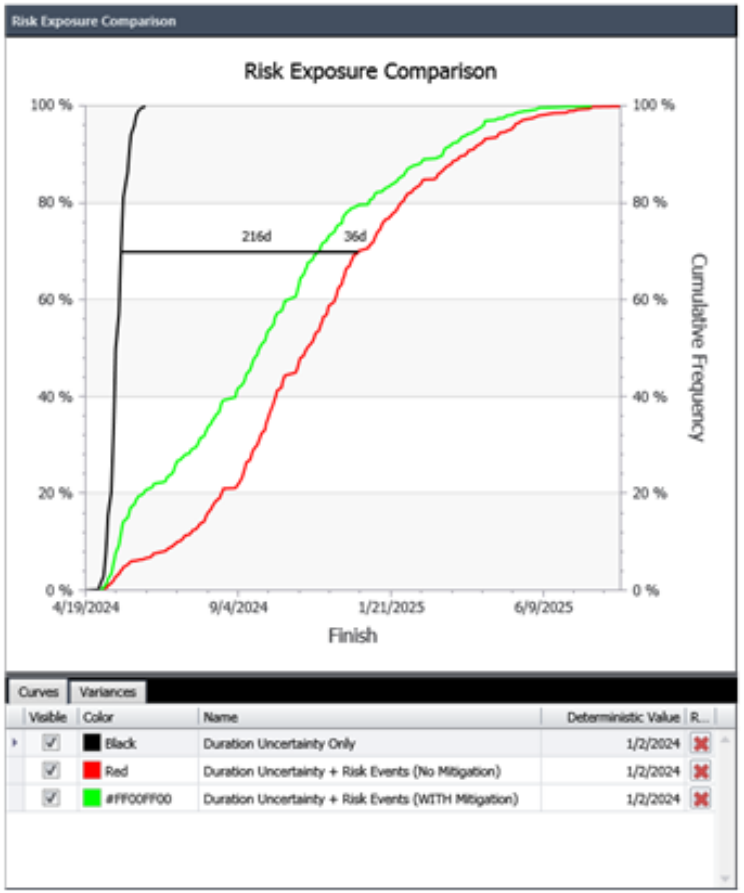
The 70th percentile of the distribution is a schedule delay of 140 days.

Summary Figure for Schedule Risk Analysis



Schedule Uncertainty Ranges

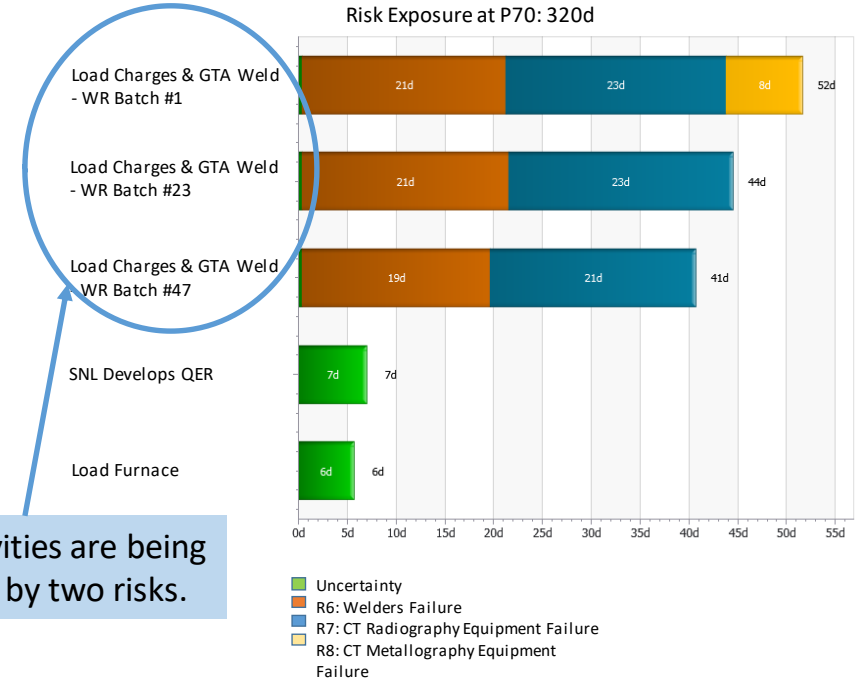
Identifier	Min %	Most Likely %	Max %
A: Very Conservative	75	90	105
B: Conservative	85	95	110
C: Realistic (1%)	95	100	115
D: Aggressive (39%)	100	110	125
E: Very Aggressive (48%)	100	115	150



P70: 140 days is schedule uncertainty, 356 days is full risk exposure, and 320 days is with mitigations.

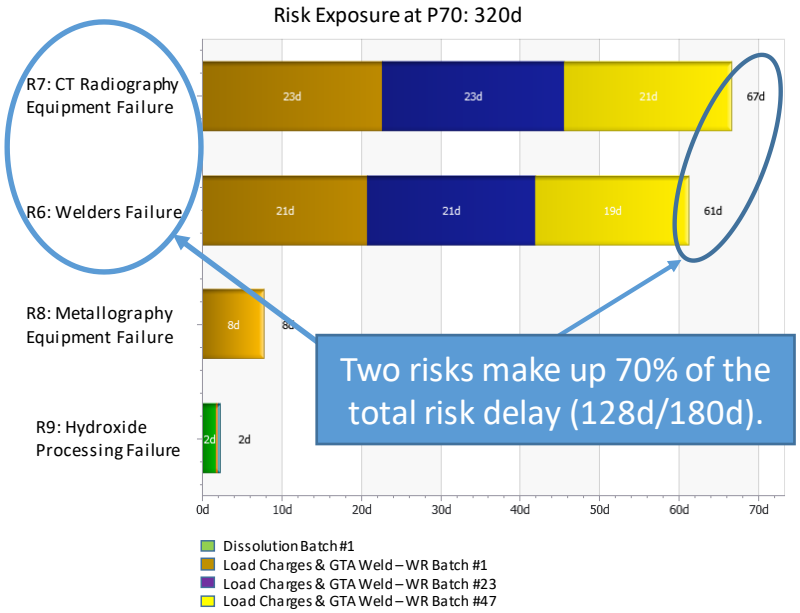
Tornado Charts Show Where the Schedule Delay is Coming From

Activity View



Three activities are being impacted by two risks.

Risk View



Two risks make up 70% of the total risk delay (128d/180d).

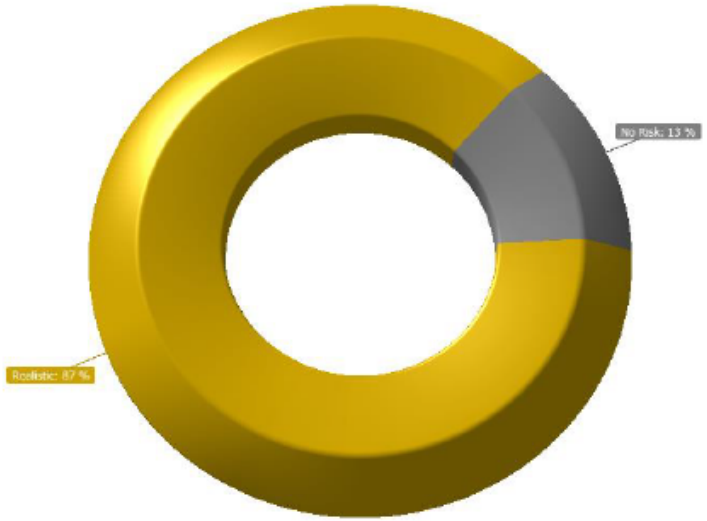
	Handling Plan			Target			
ID	Description	Duration	Cost	Probability	Schedule	Cost	ARM Score {2}
R1	Mitigate: Replace aging chillers (proposed)	130d	$30,000	Very Low (10%)	10d, 20d, 30d	Nil	1
R2	Mitigate: Replace Decon Hood (proposed)	100d	$500,000	Very Low (10%)	5d, 10d, 25d	Nil	1
R3	Accept	n/a	n/a	Low (20%)	5d, 10d, 25d	$0.1M, $0.2M, $0.3M	1
R4	Accept	n/a	n/a	Low (25%)	10d, 50d, 60d	$0.1M, $0.2M, $0.3M	2
R5	Mitigate: Replace equipment (proposed)	260d	$2,600,000	Very Low (10%)	Nil	Nil	1
R6	Accept	n/a	n/a	Medium (50%)	10d, 20d, 45d	$0.1M, $0.2M, $0.3M	3
R7	Accept	n/a	n/a	Medium (50%)	20d, 30d, 40d	$0.1M, $0.2M, $0.3M	3
R8	Accept	n/a	n/a	Low (20%)	10d, 30d, 45d	$0.05M, $0.1M$, $0.2M	1
R9	Mitigate: Improve equipment and processes	25d	$100,000	Very Low (10%)	5d, 10d, 15d	Nil	1
R10	Mitigate: Coordinate schedules	20d	$2,000	Very Low (10%)	5d, 10d, 15d	Nil	1
R11	Mitigate: Replace equipment	260d	$1,770,000	Very Low (10%)	Nil	Nil	1

Cost Risk Analysis (CRA)

- CRA builds on the predicted schedule slip result from the SRA to provide a probabilistic management reserve estimate for the project.
- Inputs are:
  - logic-linked resource-loaded schedule that includes LOE tasks definition of activity cost uncertainties
  - Risk register and mapping of risks to activities.
- Results are: S-curves, tornado charts, and MR values.

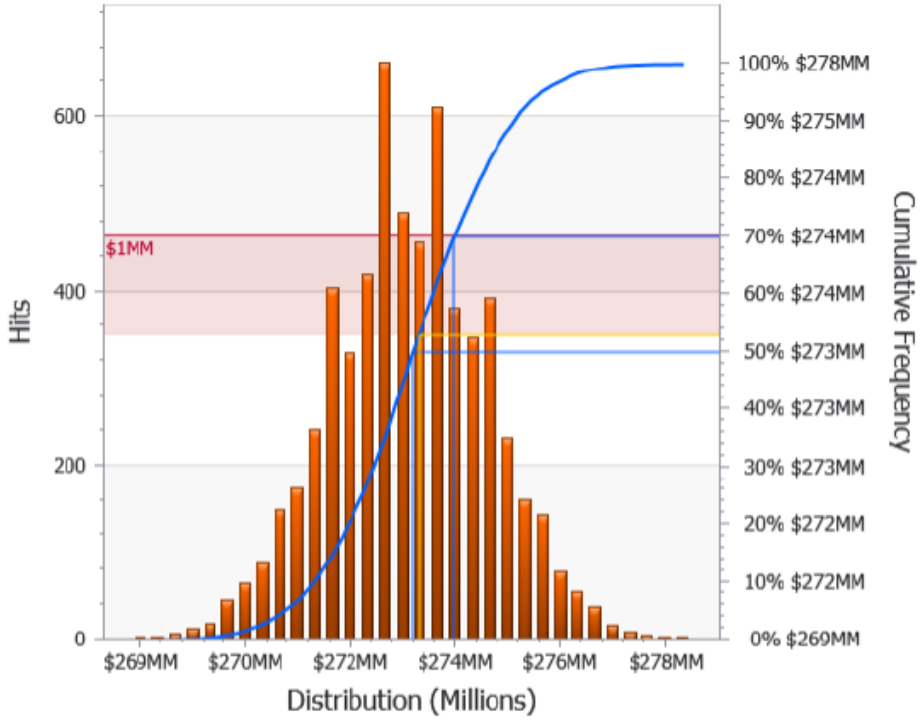
CRA–Base Cost Uncertainty

Discrete and LOE activities =
Realistic (87%)



Cost Uncertainty Ranges (Optimized)

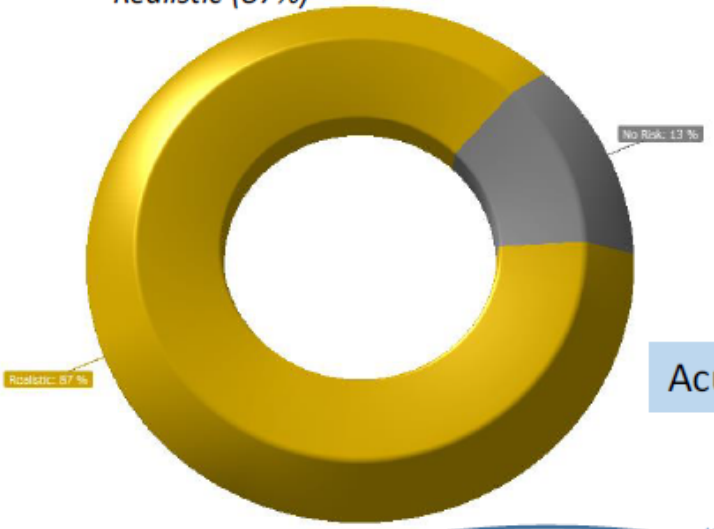
Identifier {1}	Min %	Most Likely %	Max %
Very Conservative	50	100	100
Conservative	75	100	105
LOE	95	100	105
Realistic (87%)	**90**	**100**	**110**
Aggressive	95	100	125
Very Aggressive	100	100	150



At P70, optimized base cost uncertainty MR is $1M.

CRA–With Time Overlay

Discrete and LOE activities =
Realistic (87%)

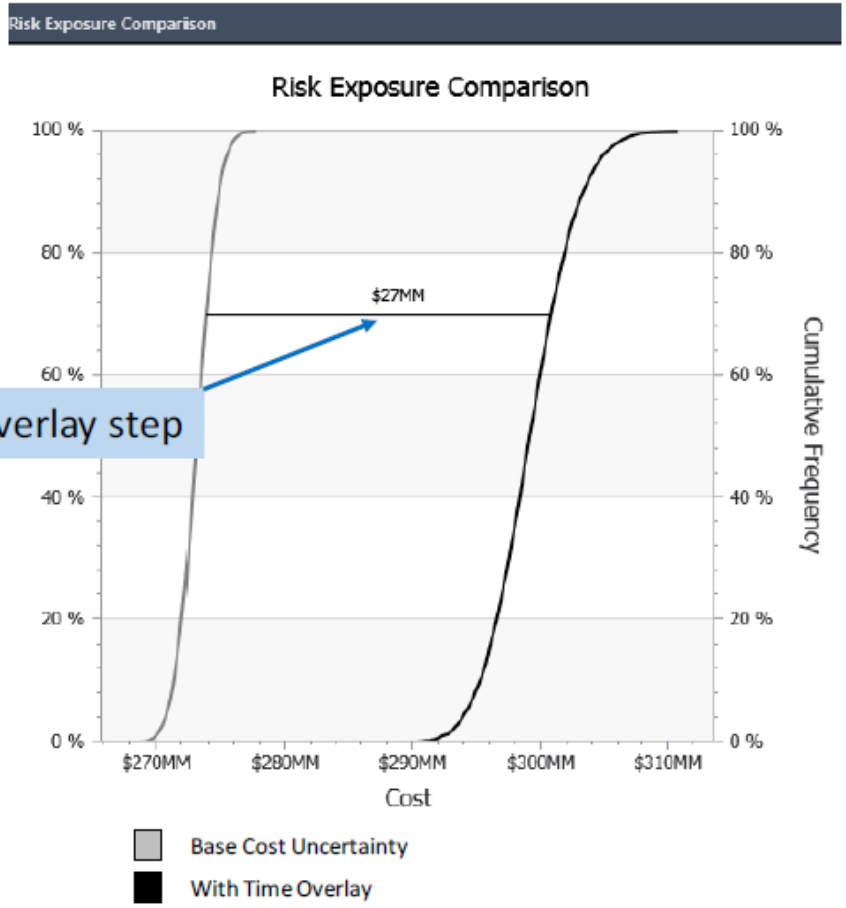


Time Overlay:	Minimum	Maximum
	105%	125%

Cost Uncertainty Ranges (Optimized) with Time Overlay

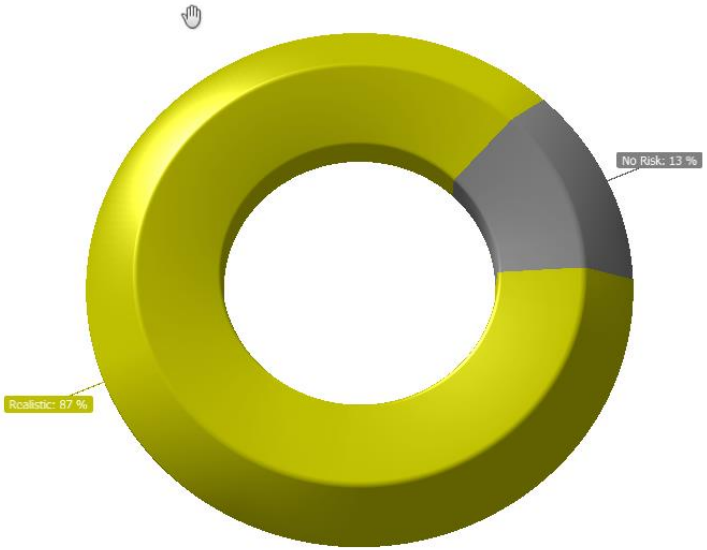
Identifier	Min %	Most Likely %	Max %
Very Conservative	53	100	125
Conservative	79	100	131
LOE	100	100	131
Realistic (87%)	**95**	**100**	**138**
Aggressive	100	100	156
Very Aggressive	105	105	188

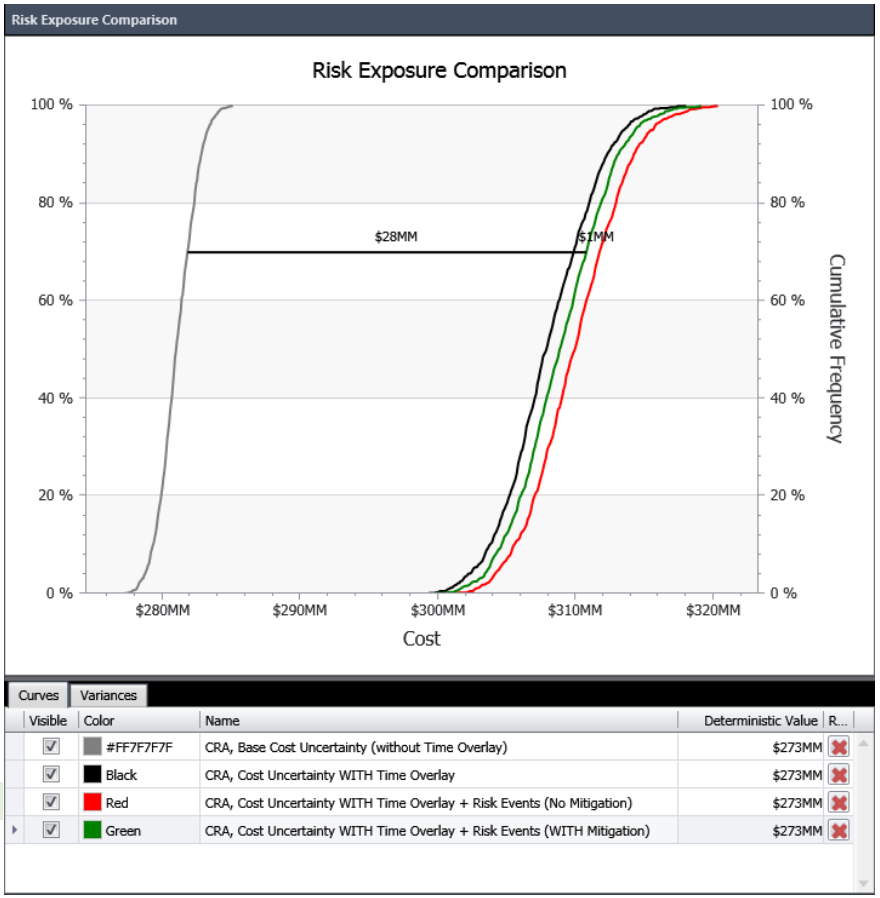
Acumen time overlay step



At P70, base cost uncertainty MR is $1M and time overlay adds $27M.

Summary Figure for Cost Risk Analysis





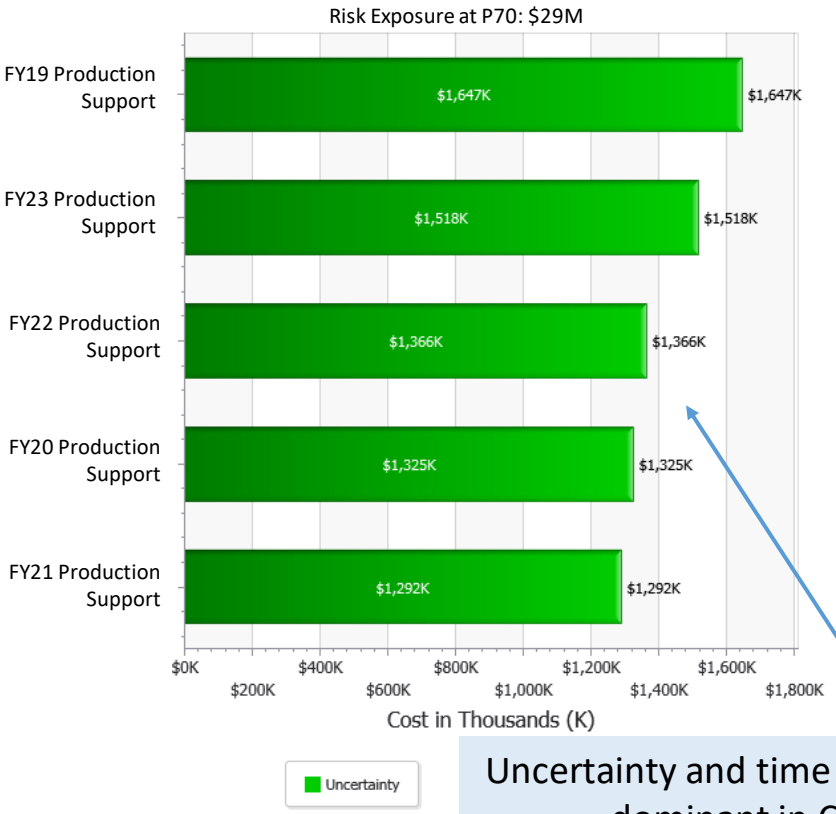
Time Overlay (Mitigated Schedule):	Minimum	Maximum
	105%	125%

Cost Uncertainty Ranges with Time Overlay

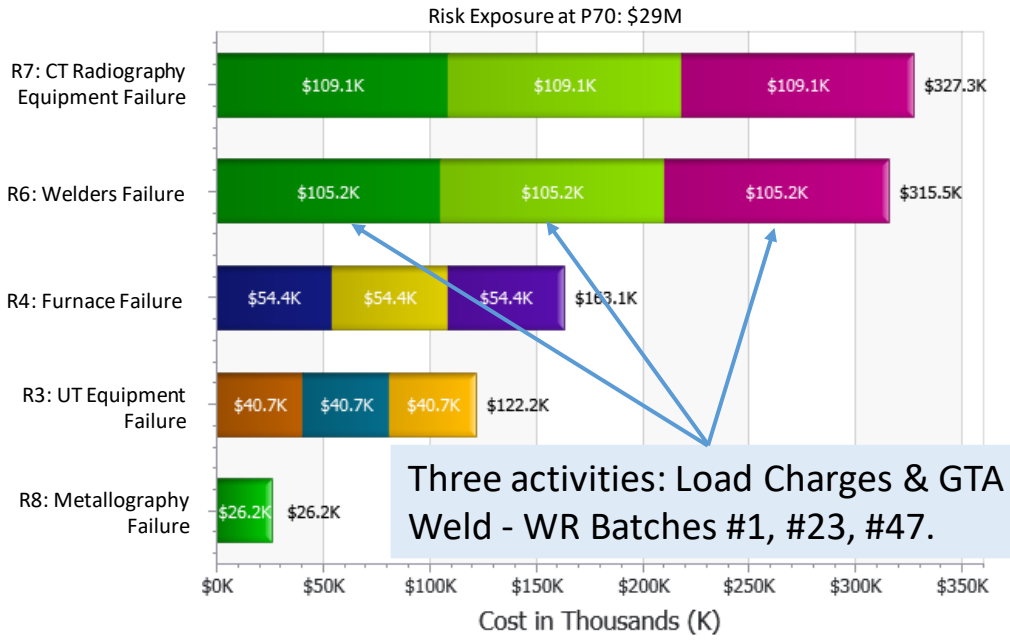
Identifier	Min %	Most Likely %	Max %
A: Very Conservative	79	90	131
B: Conservative	89	95	138
C: Realistic (87%)	**100**	**100**	**144**
D: Aggressive	105	110	156
E: Very Aggressive	105	115	188

At P70, total MR is $29M: $1M for base uncertainty, $27M for time overlay, and $1M for mitigated risks.

Tornado Charts Show Where the Cost Increase is Coming From

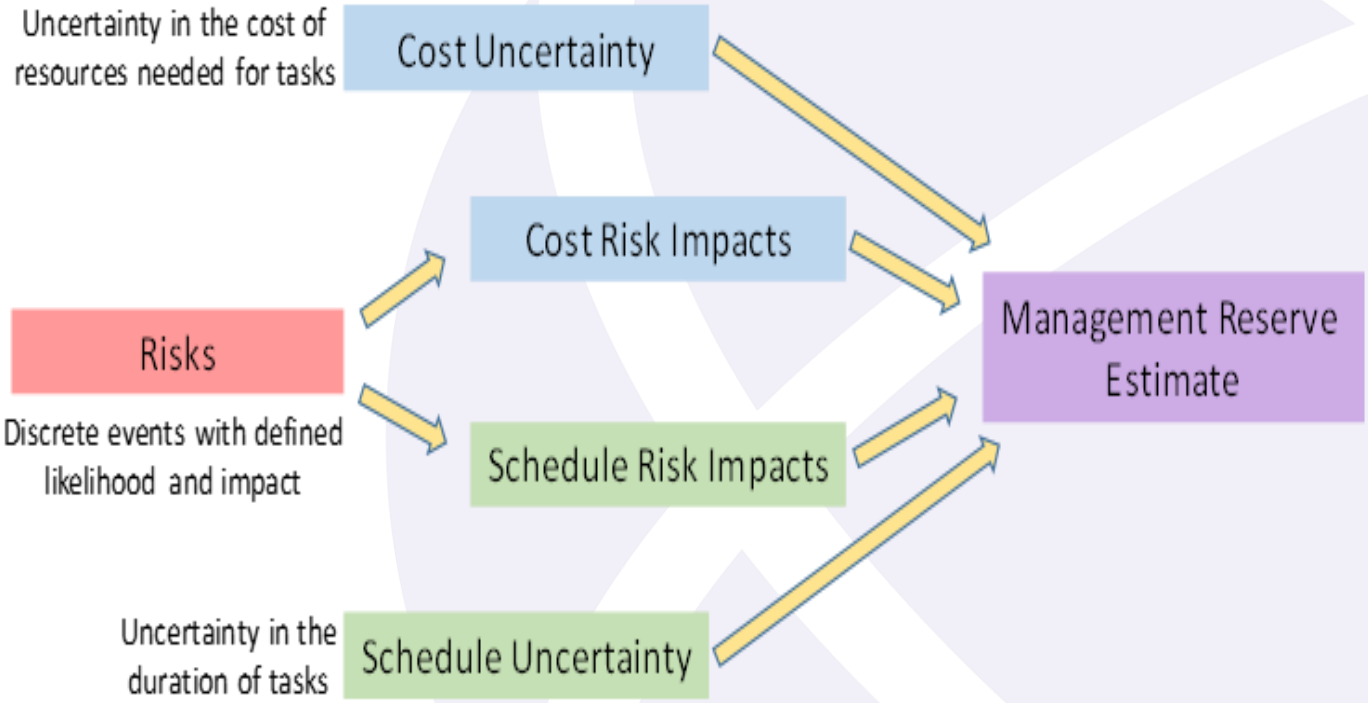


Uncertainty and time overlay are dominant in CRA.



Three activities: Load Charges & GTA Weld - WR Batches #1, #23, #47.

Risk and Uncertainty Overview



Sources

- Booth, Steven. *Application and Interpretation of Acumen Risk® Schedule and Cost Risk Analysis, January 2021. LA-UR-21-20247.*

- Ascoli, Karen; Madonia, Mike*. Plutonium Program Office (NA-191) — Plutonium Modernization Program, Risk and Opportunity Management Plan (ROMP)*, August 2020.